DOE/EM-0373

INNOVATIVE TECHNOLOGY
Summary Report

Out-of-Tank Evaporator Demonstration

Tanks Focus Area

Prepared for
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Summary Report

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OST Reference #20

Tanks Focus Area

Demonstrated at
U.S. Department of Energy
Oak Ridge National Laboratory
Melton Valley Solidification Facility
Oak Ridge, TN

INNOVATIVE TECHNOLOGY
Summary Report

Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available online at http://em-50.em.doe.gov under "Publications".

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SECTION 1

SUMMARY

Technology Summary

Approximately 100 million gal of liquid waste is stored in underground storage tanks (USTs) at the Hanford Site, Idaho National Engineering and Environmental Laboratory (INEEL), Savannah River Site (SRS), and Oak Ridge Reservation (ORR). This waste is radioactive with a high salt content. The U.S. Department of Energy (DOE) wants to minimize the volume of radioactive liquid waste in USTs by removing the excess water. This procedure conserves tank space; lowers the cost of storage; and reduces the volume of wastes subsequently requiring separation, immobilization, and disposal.

The Out-of-Tank Evaporator Demonstration (OTED) was initiated to test a modular, skid-mounted evaporator. This project was jointly funded by the DOE Office of Science and Technology (OST) and the Oak Ridge National Laboratory (ORNL) Waste Management and Remedial Action Division (WMRAD).

A mobile evaporator system manufactured by Delta Thermal Inc. was selected. The evaporator design was routinely used in commercial applications such as concentrating metal-plating wastes for recycle and concentrating ethylene glycol solutions. The system had the following features:

- subatmospheric design to reduce energy use and scaling of heat transfer surfaces because of lower boiling temperatures,
- vapor separation section for achieving a high-purity distillate,
- transportable with three main skids: feed tank/concentrate recycle unit, main evaporator unit, and a distillate receiving tank (see Figure 1 and Appendix B),
- modular concrete shielding around the feed tank/concentrate recycle and evaporator skids to reduce radiation dose to personnel,
- surveillance cameras mounted at key positions for continuous, real-time monitoring of the operation,
- operated remotely from a computerized control room in a nearby building to protect personnel from radiation doses,
- versatile instrument interface easily adapted for future needs and capable of adaptation to conditions at other sites, and
- computerized graphical user interface.

Since the demonstration system is movable, existing facilities can be used for requirements such as secondary containment and utilities. Also because it is easily transportable, capital investment will be minimized if other groups decide to utilize the system rather than building new, stand-alone facilities.

Demonstration Summary

In FY 1995, the skid-mounted evaporator system was procured and installed in an existing ORNL facility (Building 7877) with temporary shielding and remote controls. The evaporator system was operational in January 1996. The system operated 24 h/day and processed 22,000 gal of Melton Valley Storage Tank (MVST) supernatant. The distillate contained essentially no salts or radionuclides. Upon completion of the demonstration, the evaporator underwent decontamination testing to illustrate the feasibility of hands-on maintenance and potential transport to another DOE facility.

ORNL's WMRAD assumed responsibility for the evaporator system. With the support of the researchers involved in the demonstration, WMRAD is upgrading the system to process additional supernatant. After FY 1998, the system will be used in conjunction with the Cesium Removal System in future routine operations at ORNL and other sites. A similar system was being developed for treatment of SRS Consolidated Incinerator Facility (CIF) waste.

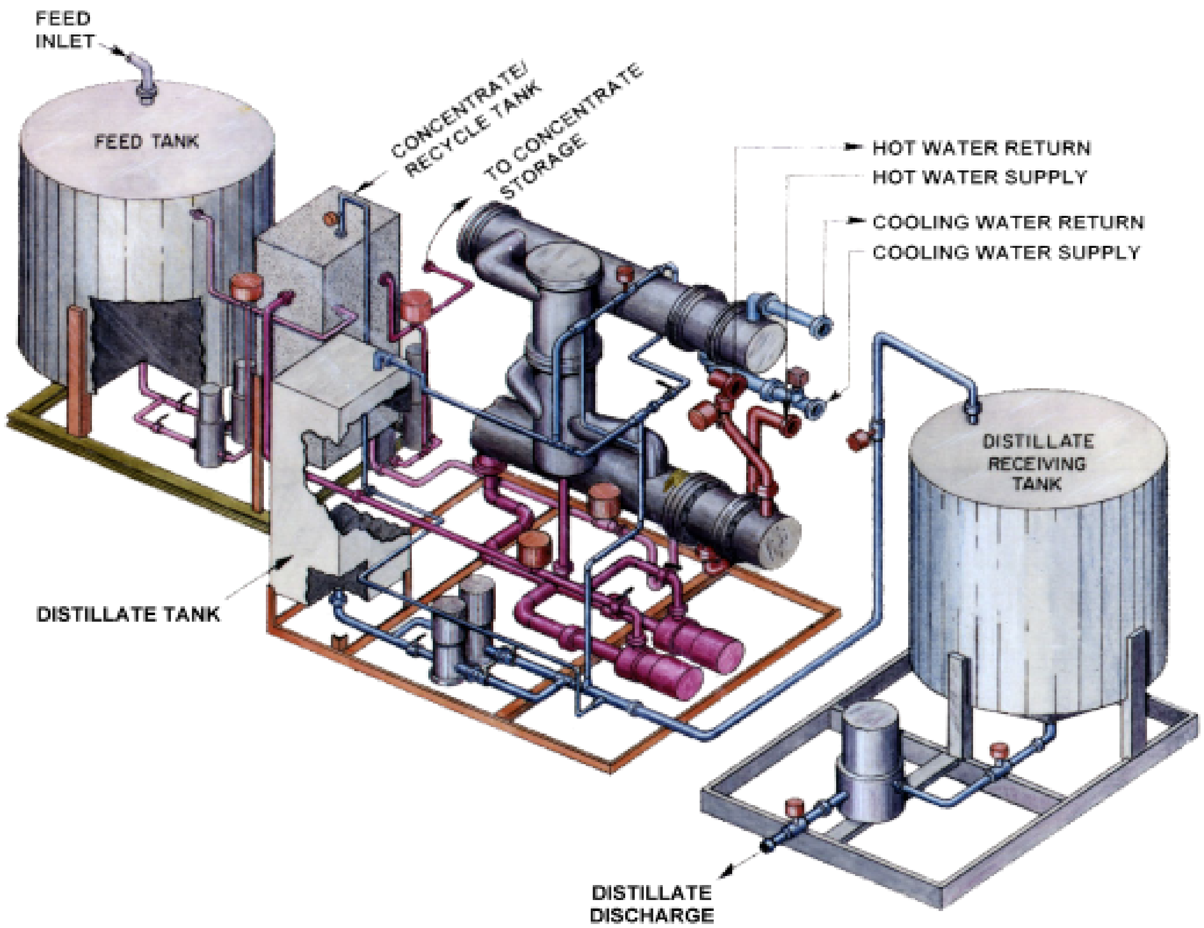

Figure 1. Out-of-tank Evaporator Demonstration system.

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All published Innovative Technology Summary Reports are available at http://em-50.em.doe.gov. The Technology Management System, also available through the EM-50 Web site, provides information about OST programs, technologies, and problems. The OST Reference # for the Mobile Evaporator is 20.

SECTION 2

TECHNOLOGY DESCRIPTION

Overall Process Definition

ORNL currently stores about 450,000 gal of concentrated radioactive liquids and sludges in twelve 50,000 gal USTs in the Melton Valley and Bethel Valley areas. As the near-term management strategy, waste generators are required to minimize the volume of additional wastes being transferred into these tanks. In the past, a process called in-tank evaporation was applied to evaporate excess water in the tanks by using an ambient air sparging technique; however, this technique is not used anymore because it is a much slower process than other methods. Additional baseline processes at ORNL include grouting of tank supernatant prior to disposal at the Nevada Test Site (NTS), storing of the waste for approximately 15-20 years in tanks, and treating the sludges in a line-item facility for disposal at NTS or the Waste Isolation Pilot Plant. Grouting processes, however, have proven to be costly, and they produce additional wastes.

To avoid generating excessive solidified waste, an evaporator was proposed to remove excess water from the waste and create additional storage space. As a result, the Tanks Focus Area of EM-50 and the ORNL WMRAD cofunded the demonstration of a remotely operated, skid-mounted, mobile evaporator system for processing contaminated waste from USTs owned by ORNL. In August 1997, baseline plans were revised to replace supernatant grouting with an evaporator.

System Operation

The evaporator system met or exceeded all performance criteria. Effective performance of the system was defined as concentrating the MVST supernatant by 25 volume percent while producing distillate at a rate of 1 gpm. Distillate composition complied with the waste acceptance criteria (WAC) at ORNL's Process Waste Treatment Plant (PWTP). The WAC required that the evaporator system achieve a decontamination factor (DF) of about 2 to 9 million. The DF is the ratio of the feed material's activity entering the process to the activity of the effluent exiting the process.

The single-stage, subatmospheric evaporator concentrated 22,000 gal of liquid-low level waste (LLLW) stored in ORNL's MVSTs. The original LLLW volume was reduced to 16,500 gal (75 percent of the original feed) of concentrated supernatant, which was returned to MVSTs. The waste feed contained approximately 8.5×10^8 bequerels per liter (Bq/L) cesium-137 and 4.5 Molar (M) sodium nitrate and yielded a concentrate stream containing approximately 6 M sodium nitrate and most of the contaminants. The distillate stream contained essentially no salts or radionuclides. DFs during the demonstration ranged from about 3 to 9 million, with an average of 5 million. The 5,500 gal of distillate was disposed of at ORNL's PWTP. Operating parameters were monitored closely throughout the process.

Process Description

The evaporator is a mobile, single-stage, subatmospheric evaporator. Each component of the system is separately skid-mounted. The system feed can produce 90 gal/h of distillate and is designed for remote operation from a nearby control building. Figure 2 depicts the evaporator operation process. The evaporator operates as follows:

- The evaporator feed tank (400-gal capacity) is filled in batches.
- Feed is added until to the concentrate loop until it reaches the operating level. After filling the concentrate loop, the heaters are energized and processing begins.
- Feed is continuously added to the concentrate loop to maintain the desired operating level.
- The vapor produced is condensed, cooled, and collected in the condensate holding tank.

- When the condensate holding tank is full, the condensate is transferred to liquid effluent treatment.
- When the concentrate reaches the desired specific gravity, a valve is opened to allow a portion of the concentrate to be drained to an MVST.
- When the feed tank reaches a low level, the evaporator is automatically placed in a closed-loop configuration so that waste can be transferred to the feed tank. While in closed loop, the condensate is recycled, and concentrate transfer to the receiving tank is discontinued. Once the feed tank is filled, the evaporator can resume the steady-state discharge of both concentrate and condensate waste.
- When waste processing is completed, decontamination is required to allow hands-on maintenance and transport of the evaporator system.

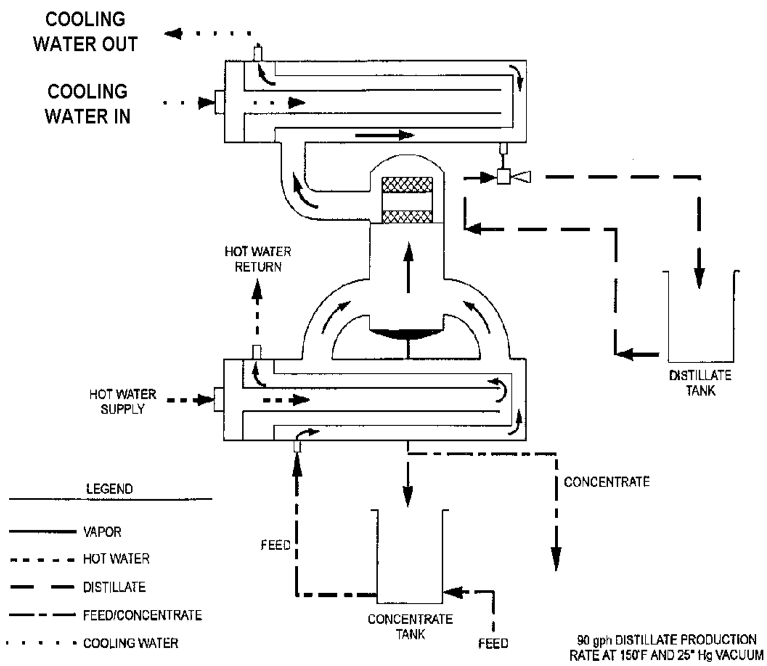

Figure 2. Basic flow diagram of the Out-of-Tank Evaporator.

SECTION 3

PERFORMANCE

Demonstration Overview

The project used modular, skid-mounted equipment to process radioactive liquid waste stored in ORNL's MVSTs. During the 8-day demonstration, 22,000 gal of LLLW (about 10 percent of the present MVST inventory) was concentrated by 25 volume percent using the evaporator system. Of this total, about 16,500 gal of concentrated liquid was returned to MVSTs and 5,500 gal of distillate was disposed of at ORNL's PWTP.

Following the demonstration, studies were performed to evaluate the ability to flush and decontaminate the system so that hands-on maintenance could be performed. This illustrated the feasibility of moving the evaporator system to another DOE site.

Performance Assessment Objectives

A primary objective of this demonstration was to study technical and programmatic issues that would impact mobile evaporator technology. Examples of such issues include the following:

- achievable DF (cleanliness of the overhead condensate) for the unit under various operating conditions,
- fouling tendencies of the system,
- heat transfer coefficients,
- maximum processing rate for the system compared to the design capacity,
- ease of operation, frequency of down time, and maintenance requirements,
- radiation shielding requirements for reduced worker exposure,
- the process economics,
- capital versus expense requirements, and
- required regulatory documentation.

Operational Performance

Evaporator performance met or substantially exceeded expectations based on bench-scale tests with surrogate wastes. Skid-mounted equipment was demonstrated as a viable alternative for treatment of ORNL LLLW and hands-on maintenance and decontamination for movement to another site was achieved. Specific operational accomplishments included:

- The activity of cesium-137 in the feed stream (8.5×10^8 becquerel/liter [Bq/L]) was reduced to 1.5×10^2 Bq/L in the distillate, which was significantly less than the waste acceptance limit (4×10^2 Bq/L) for disposal at ORNL's PWTP.
- The radioactive exposure was reduced to less than 20 millirems per hour (mR/h) during operations by placing concrete shielding around the evaporator skids.
- "Hands-on" maintenance was demonstrated. After 6 days of operation, the system was shut down to repair a failed control valve actuator. After flushing the evaporator with tap water, workers performed hands-on repairs and received less than 10 mR exposure.

- Upon completion of operations, only three water rinses were required to lower the background radiation throughout the system. Radiation background was reduced from up to 7 R/h to less than 5 mR/h without the use of acid.
- When radiation background was sufficiently reduced to allow direct access to equipment, about six areas were identified where small leaks (less than 20 ml total) had contaminated the exterior surfaces of equipment. These areas were decontaminated with water and dilute nitric acid rinses. The sources of the seepage were identified as valve stems and pump drain plugs. Minor modifications to address expansions and contractions from temperature changes should eliminate leaks during future operations.
- A computer model accurately predicted radiation fields so that only minor rearranging of shielding was required during the demonstration to shield doses from "hot spots." Radiation exposure to personnel was maintained well below the administrative control limits for the project.

The results from the demonstration were used to recommend upgrades before installation into WMRAD operations at ORNL and/or procurement of similar systems at other DOE sites. These upgrades are primarily related to modifications of the valves and to improve the energy efficiency of the system. The evaporator upgrades began in FY 1997, and they were completed in November 1997.

Future Plans

ORNL will consolidate waste from four tank farms into the MVSTs between FY 1997 and FY 2000. Ongoing research and reactor operations at ORNL also generate LLLW, which is sent to the MVSTs. Until the new MVSTs become operational in early FY 1999, the supernatant and sluice waters in existing MVSTs will be concentrated to recover tank space. The evaporator will be operated in batch mode from December 1997 through June 1998. Approximately 100,000 gal of supernatant will be concentrated to approximately 50,000 gal. The dilute condensate will be routed to the liquid effluent treatment facility.

The evaporator will then be modified to operate in series with the Cesium Removal System. This configuration will ensure that cesium DF in the evaporator distillate are met. Start-up is expected for the integrated system in January 1999. In 1999 and 2000, the integrated evaporator and cesium removal system will concentrate and/or decontaminate liquid waste prior to transfer to new MVST tanks. The system will be operated in a semibatch mode.

The deployment of a mobile evaporator system is planned at the SRS CIF. The SRS CIF is a mixed, hazardous, and low-level radioactive waste incinerator which began hot operation in April 1997. The incinerator uses dilute caustic solution to scrub contaminants from the incinerator off-gas. The evaporator will concentrate 50,000 gal/year of CIF blowdown solution to 10,000–15,000 gal/year, thus reducing the amount of waste requiring grouting and disposal by up to 80 percent. In addition, the evaporator system would allow the CIF off-gas system to be operated at a lower salt concentration, which would extend the high-efficiency particulate air (HEPA) filter life by a factor of four (from 1–2 weeks to 4–8 weeks).

System specifications will be refined during the vendor qualification phase prior to system procurement. The evaporator will concentrate the blowdown to 20-25 weight percent total dissolved solids. Existing tanks will be used as the evaporator feed, distillate, and concentrate tanks. The CIF has all the required utilities, including steam. The evaporator overheads will be recycled to the existing off-gas system, and the concentrate will be solidified in the existing grouting system. Three process skids are to be provided by the vendor: the evaporator, the glycol heater, and an air-cooled heat exchanger. Due to the presence of chlorides, the system will need to be constructed of an acid-resistant material (Hastelloy). The system will be fully automated.

SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Technology Applicability

Within the DOE complex, wastes from approximately 300 USTs are being remediated with support from the Tanks Focus Area (TFA). The USTs have been used to process and store radioactive and chemical mixed waste generated from weapon materials production and energy research. Together, these tanks hold about 90 million gal of high-level and low-level radioactive liquid waste, very little of which has been treated and disposed of in final form. At ORNL, approximately 1 million gal of LLLW is stored in USTs.

The out-of-tank evaporator technology offers a cost-effective and efficient alternative for minimizing LLLW volumes for interim storage before treatment and final disposal. The technology can be used to create space in the double-shell tanks (DSTs) so that waste from noncompliant, single-shell tanks can be moved to compliant tanks (i.e., DSTs).

Several DOE programs will benefit from implementation of the evaporator system:

- The ORNL WMRAD plans to use the technology to provide waste management services for on-site research and reactor programs.
- The ORNL Environmental Restoration program could benefit from the additional storage capacity provided by the evaporator, which would allow storage of some of the liquid wastes now residing in a number of inactive USTs such as the gunite tanks.
- At SRS, evaporator technology could significantly reduce the volume of CIF blowdown waste.

Competing Technologies

In the past, an ITE process using ambient air sparging was applied to evaporate excess water in the tanks; however, this technique is not used anymore because it is a much slower process. Additional processing at ORNL includes grouting tank supernatant without concentrating prior to disposal at the NTS or storing of the waste for approximately 15–20 years in tanks.

Technology Maturity

In FY 1995, the skid-mounted evaporator system was procured and installed in an existing facility (Building 7877) at ORNL with temporary shielding and remote controls. In FY 1996, the demonstration was conducted to demonstrate the operation of full-scale, modular, subatmospheric evaporator system. A total of 22,000 gal of LLLW supernatant was processed, producing 5,500 gal of distillate that met the waste acceptance criteria for liquid effluent treatment and disposal. Upon completion of the demonstration, ORNL's WMRAD assumed responsibility for the evaporator system. With the support of the researchers involved in the demonstration, WMRAD is upgrading the system to process an additional 175,000–200,000 gal of tank supernate liquids. ORNL is combining the mobile evaporator system with the Cesium Removal System to treat newly generated LLLW in FY 1999. In addition, SRS is evaluating using this system to reduce the volume of CIF blowdown liquids that are processed to a grout waste form.

Patents/Commercialization/Sponsors

OST (EM-50) and the ORNL WMRAD (EM-30), cofunded the installation, testing, and operation of the evaporator. A memorandum of understanding (MOU) was signed between ORNL's EM-30 and EM-50 on June 1, 1994, defining EM-30 and EM-50 responsibilities for the jointly funded task. The MOU stated that EM-50 would provide approximately $1.5 million to install and demonstrate the evaporator; and EM-30 would provide $1.5 million to procure the evaporator, modify it for long-term operation, and operate the unit after the initial EM-50 demonstration.

In FY 1998, a new task was funded to develop an evaporator system for treatment of incinerator off-gas scrub solution at SRS. ORNL will collaborate with SRS in all phases of the experimental work. ORNL will also provide technical support for pilot-scale testing and engineering studies at SRS. ORNL will share information and experience gained through the FY 1996 demonstration of the modular evaporator concept for treatment of the MVST waste.

The integrated evaporator and cesium removal project initiated in FY 1998 is funded by multiple organizations. This project requires a budget of approximately $21 million in the next four years with $9.4 million coming from the OST Accelerated Site Technology Deployment (ASTD) Program and the remaining from leveraged ORNL and SRS funds.

Delta Thermal Systems, Inc. of Pensacola, Florida (formerly Mobile, Alabama), constructed the ORNL evaporator system with guidance from ORNL Engineering. Upon completion of the demonstration, ORNL's WMRAD assumed responsibility for the evaporator system. This division is currently upgrading the system to process additional waste.

SECTION 5

COST

Summary

The cost savings result from reducing the volume of LLLW. This reduces costs for grouting operations, transportation, and disposal at NTS. Life cycle cost savings are $47 million from the ORNL FY 1996 demonstration, the subsequent ORNL treatment of MVST waste, and the SRS CIF evaporator deployment.

ORNL Evaporator

Cost estimates are summarized in Table 1 for innovative and baseline technologies. The estimates are based on the following assumptions:

- In FY 1996, approximately 22,000 gal of ORNL legacy supernatant was concentrated by 25 percent, eliminating solidification and disposal costs for 5,500 gal of supernate at NTS.
- From December 1997 through June 1998, 100,000 gal of waste will be concentrated to a volume of 50,000 gal and transferred to another MVST. Solidification and disposal costs for 50,000 gal of supernate will be eliminated because the distillate is transferred to the PWTP for further treatment and discharge to the environment.
- In FY 1999, the integrated evaporator and cesium removal system will be operated to concentrate and/or decontaminate liquid waste prior to transfer to the new MVST tanks. Implementation of the evaporation and cesium removal system will reduce the volume of supernatant requiring treatment for disposal at NTS by 210,000 gal from 1998 to 2002.
- Immobilizing the waste stored in the MVST through privatization will occur between FY 2002 and 2006. The supernatants in the MVST will be solidified in grout.

Table 1. Comparison of treatment and disposal costs in millions of constant 1999 dollars for Oak Ridge evaporator versus grouting and cesium removal

Baseline		Evaporator and Cesium Removal	
Supernate treatment and disposal (525,500 gal @ $150/gal	78.8	Capital costs	5.4
		Operating costs	3.7
		Crystalline silicotitanate disposal	1.6
		Decommission cost	0.5
		Supernate treatment and disposal (260,000 gal @ $50/gal	13.0
		Total	24.2

- If evaporation had not been accomplished, the total volume of waste sent to grout would be 525,500 gal. With evaporation, the total volume of waste to grout is reduced by 50 volume percent to approximately 263,000 gal.

- According to Oak Ridge estimates, the cost of solidifying supernate with cesium is $150/gal and $50/gal with the cesium removed. This estimate includes the costs of constructing and operating the treatment facility, transportation, and disposal costs at NTS.

SRS CIF Facility

Cost estimates are summarized in Table 2 for innovative and baseline technologies. The estimates are based on the following assumptions:

- The blowdown volume from the scrubber off-gas system is expected to be 50,000 gal/year containing 5 to 8 weight percent total dissolved solids. Concentration to 20-25 weight percent solids reduces this volume to 10,000 gal/year. This process reduces the expenditures for grouting, transportation and disposal from $903K/year to as little as $153K/year.

- The evaporator system would allow the CIF off-gas system to be operated at a lower salt concentration, which would extend the HEPA filter life from 1–2 weeks to 4–8 weeks, reducing the replacement costs from $559K/year to as little as $70K/year.

Table 2. Comparison of treatment and disposal costs in millions of constant 1999 dollars for SRS CIF evaporator application and grouting

Parameter	Grouting	Mobile evaporator
Capital costs		1.86
Operating costs		4.9
Waste disposal	8.13	1.22
HEPA filter replacement	5.03	0.56

Cost Savings and Avoidance

Life-cycle cost savings are estimated at $44 million for currently planned applications of the mobile evaporator. A discounted cash flow analysis[1] indicates that the present value (PV) of the cost for supernatant treatment with the evaporator and Cesium Removal System at Oak Ridge is approximately $20 million. Without cesium removal, the costs would have been over $60 million. This innovation represents a cost savings of over $43 million at ORNL. Similarly, the PV of cost savings at SRS is calculated to be approximately $4 million. Actual SRS cost savings may be even greater, as all the operational benefits of the system are realized.

[1] The cost savings were calculated from the difference in the net present value of the baseline and innovative technologies. The net present value is calculated by discounting the constant dollar cash flows using a discount factor of 3.5% (OMB constant-dollar discount rate, January 1998).

SECTION 6

REGULATORY AND POLICY ISSUES

Regulatory Considerations

A regulatory analysis determined the applicable federal, state, and local environmental regulations related to the mobile evaporator system. A categorical exclusion was obtained at ORNL based on National Environmental Policy Act documentation prepared by WMRAD. Resource Conservation and Recovery Act compliance is covered under an existing permit-by-rule for the ORNL demonstration facility. Condensate disposal is covered by an existing National Pollutant Discharge Elimination System Permit (TN002941) for the liquid effluent treatment facility. The requisite permits for operating the mobile evaporator (i.e., Air Permit, Safety Analysis Report) and a DOE readiness self-assessment were obtained before “hot” operation of the system.

Safety, Risks, Benefits, and Community Reaction

Worker Safety

“As low as reasonably achievable” principles were used in the technology design to minimize the potential exposure of workers to hazardous and radioactive environments. For worker protection, most operations are remotely controlled from a nearby building.

Community Safety

The risk to the community is very low because the physical process has a low accident and release potential. The evaporator system is tested and checked for leaks and malfunctions before handling radioactive tank wastes. The distillate, collected in a holding tank, is discharged to the ORNL PWTP only when it meets the waste acceptance criteria. The evaporator system is flushed with tap water and thoroughly decontaminated after each operation and before potential transportation to another site.

Potential Socioeconomic Impacts and Community Perceptions

Community	The mobile evaporator has minimal labor force impact. However, there may be economic impact due to the amount of money that can be saved by reducing the waste volume prior to its disposal. There is no adverse public or tribal input regarding the system. In fact, the technology is readily understandable to the public.
Aesthetic	It is anticipated that the system will typically be housed in existing structures. The system is also compact and therefore has minimal aesthetic impact and will not affect the capacity of the land to be released for unrestricted use.
Natural Resources	The process does not consume significant amounts of natural resources or significantly impact existing environmental resources for future use. The process uses electric energy for all its functions, which is available from existing sources at any future host site.

Benefits

Pretreatment of DOE UST waste is a common need throughout the DOE complex. Benefits of evaporation to pretreat LLLW at DOE sites include the following:

- The process significantly reduces radioactive liquid waste volume.
- Volume reduction of the waste creates space in existing DSTs enabling waste to be moved from noncompliant storage tanks to environmentally compliant tanks.
- The process does not generate significant amounts of secondary waste.

The demonstration of this evaporator system proved that it is feasible to utilize mobile, modular processing equipment to evaporate LLLW from the USTs. The demonstration provided information on the actual costs and effectiveness of this concept under full-scale conditions. The DF and the feed processing rate devised as part of the demonstration is useful to other DOE organizations in developing process flow sheets for waste treatment at their sites.

SECTION 7

LESSONS LEARNED

The demonstration results show that bench-scale information can be scaled-up to predict full-scale performance. The results also indicate that this type of evaporator system should be considered for application across the DOE complex for concentrating LLLW. With minor modifications, the integrated evaporator and cesium removal system will provide for long-term baseline operations that meet ORNL user needs. The system has been transferred to WMRAD for this purpose.

Implementation Considerations

Multisite deployment of environmental technologies within the DOE complex often encounter unexpected barriers to successful implementation. Project personnel at ORNL are committed to ensuring successful implementation of future demonstrations at other DOE sites. It has been ORNL's experience that by involving personnel from other sites in the demonstration, barriers can be broken down. Involvement can be in terms of the following:

- site visits to ORNL during operating periods and demonstrations,
- close communication to ensure technical and regulatory issues are addressed,
- hands-on training with equipment, and
- access to data generated on the projects.

Another consideration in future implementation of the mobile evaporator is to ensure that future regulatory permits and documentation are developed with enough flexibility to allow for updates and modifications as equipment or processes are changed.

Technology Limitations and Need for Future Development

Tests to determine that the evaporator can meet the ORNL user requirements and performance specifications were completed during the demonstration. Key information obtained from the demonstration included performance data (e.g., production rate, effluent purity, system operating efficiency), reliability and operating experience, and experience decontaminating the system for hands-on maintenance and possible demobilization of the system to other locations. However, the demonstration equipment was designed to process relatively low-activity waste. The system will require upgrades to handle high-activity waste. Additionally, if plans proceed, the evaporator will be operated with the Cesium Removal System. Prior to operation of the two systems in parallel, additional equipment upgrades are required. Some of the recommended upgrades and activities include the following:

- Extensive testing using nonradioactive surrogate wastes should be carried out to detect and prevent potential problems before handling radioactive tank wastes.
- Extensive planning that includes a detailed scope of work will save both time and resources, especially during the system design and installation phase.
- A more radiation-proof camera will be needed to allow closer monitoring during the radioactive waste processing.
- Accessibility to equipment for regular and emergency maintenance should be taken into consideration during the design of shielding for the skids.
- Upgrades to reduce dose rates to employees, enhance operability of the system, and allow for continuous rather than batch operation are needed.

- System piping, feed delivery system, and the computer control system need upgrading.
- Control valves will need to be upgraded to improve maintenance capability by relocating the electrical components to an accessible location outside the portable shielding walls. Several manual valves on the evaporator system need to be replaced with automatic valves.
- Installing autosamplers on feed, concentrate, and distillate sample lines to allow for remote sampling and reduction of operator radiation exposure are recommended.

The evaporator system and the demonstration were designed to produce information for applying this technology to other sites. The final demonstration has shown the feasibility of using this type of evaporator system across the DOE complex. With a few upgrades to the system, sites such as Hanford, INEEL, and SRS can reduce their waste volumes and receive many of the same benefits that were obtained at ORNL.

APPENDIX A

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APPENDIX B

DEMONSTRATION SITE CHARACTERISTICS

Site History/Background

In 1994, the DOE Office of Environmental Management created the TFA to integrate and coordinate tank waste remediation technology development efforts, which formerly had been managed by the Underground Storage Tank Integrated Demonstration. The mission of TFA is to focus the development, testing, and evaluation of remediation technologies within a system architecture to characterize, retrieve, concentrate, treat, and dispose of radioactive waste stored in USTs at DOE facilities. TFA has focused primarily on four DOE locations: Hanford, INEEL, ORR, and SRS.

ORR, established in the 1940s during the Manhattan Project, today hosts three major operating facilities: the Y-12 plant, the Environmental Management and Enrichment Facilities (K-25), and ORNL. ORNL, located in the southwest portion of the ORR in Bethel Valley, consists of nuclear research reactors, particle accelerators, hot cells, radioisotope production facilities, research facilities in the basic and applied sciences, support operations, and waste management units. The evaporator unit was built and demonstrated at the ORNL Melton Valley Solidification Facility, which was used to solidify and grout the tank wastes from the MVSTs.

Description of DOE Underground Storage Tanks

Primarily two waste storage tank types are used by DOE: single-shell and double-shell wall design (see Figure 3). These tanks are made of stainless steel, concrete, and concrete with carbon steel liners. Their capacities vary from 5000 gal to 1.3 million gal. These USTs are covered with a layer of soil which ranges from a few feet to tens of feet thick. In-tank atmospheric conditions vary in severity from near ambient temperature to temperatures over 93^{o}C.

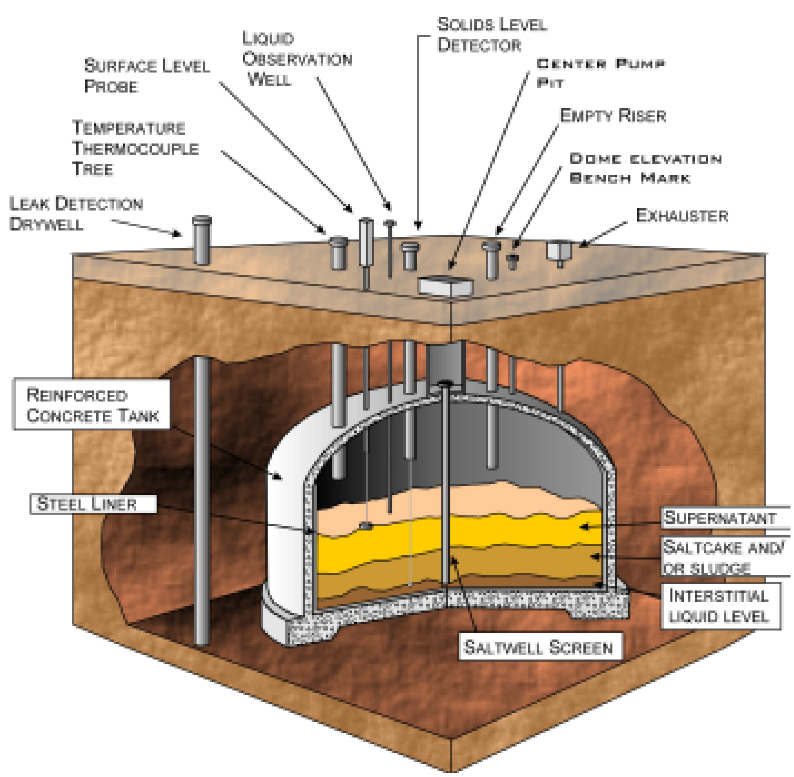

Figure 3. Example of a "typical" single-shell tank.

Contaminants of Concern

The tank wastes found predominantly at ORR, Hanford, and SRS consist of salt cake, supernate, and sludge. They are alkaline and have high concentrations of sodium and nitrates. They also contain organic material and various radionuclides, including Cs, Sr, Tc, I, and transuranics (i.e., Pu, Am). The concentrations of contaminants and the waste characteristics vary considerably from tank to tank and site to site.

APPENDIX C

PROCESS SCHEMATIC

A single-stage, subatmospheric evaporator, Figure 4, rated to produce 90 gal/h of distillate was procured from Delta Thermal Inc. of Pensacola, Florida. The system was installed in existing buildings and was shielded with concrete shielding modules purchased from Concrete Products, Inc., Memphis, Tennessee.

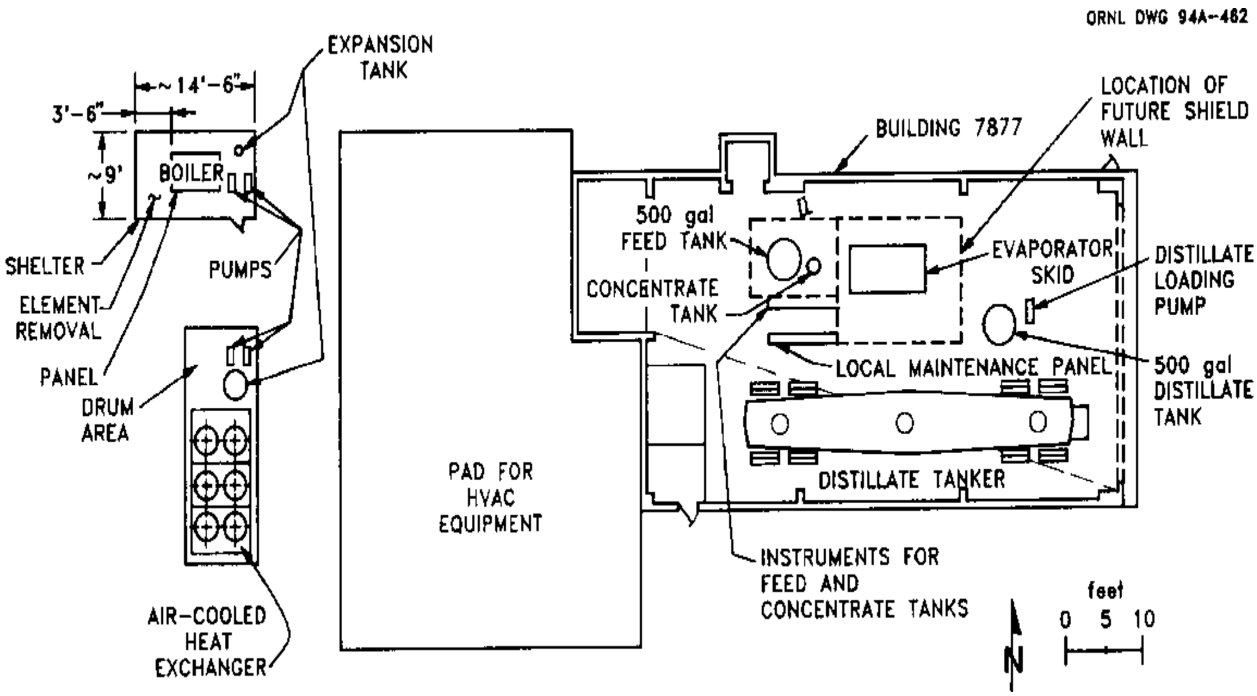

Figure 4. The out-of-tank evaporator system layout.

APPENDIX D

LIST OF ACRONYMS

ASTD	Accelerated Site Technology Deployment
CIF	Consolidated Incineration Facility
DOE	Department of Energy
HEPA	high efficiency particulate air
INEEL	Idaho National Engineering and Environmental Laboratory
LLLW	Liquid Low Level Waste
MOU	Memorandum of Understanding
MVST	Melton Valley Storage Tanks
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OST	Office of Science and Technology
OTED	Out-of-Tank Evaporator Demonstration
PWTP	Process Waste Treatment Plant
PV	present value
SRS	Savannah River Site
TFA	Tanks Focus Area
UST	underground storage tanks
WA	waste acceptance criteria
WMRAD	Waste Management and Remedial Action Division